Knowledge-based urban development performance analysis: Moving towards an integrated system

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Knowledge-based urban development (KBUD) has become the new development paradigm for the cities of the global knowledge economy era. Nevertheless, to date international KBUD performance analysis of prosperous knowledge cities is understudied. This paper, therefore, introduces the methodology and application of a novel performance analysis approach to comprehensively scrutinise the global perspectives on KBUD of cities—i.e., The KBUD Assessment Model (KBUD/AM). This indexing model puts 11 renowned knowledge cities—i.e., Birmingham, Boston, Brisbane, Helsinki, Istanbul, Manchester, Melbourne, San Francisco, Sydney, Toronto, Vancouver—under the KBUD microscope to provide a benchmarked international outlook. The results of the indexing provide internationally benchmarked snapshot of the degree of achievements in various KBUD performance areas. This paper discusses the further development avenues and potentialities of the index to become an integrated system for the policy-making circles of cities to benchmark themselves against their competitors and develop relevant KBUD policies.

Keywords

Expert system, indexing model, KBUD/AM, Knowledge-based urban development (KBUD), Knowledge city, Performance analysis

1. Introduction

Knowledge-based urban development (KBUD) is defined as the new development paradigm of the global knowledge economy era that aims to bring economic prosperity, socio-spatial order, environmental sustainability, and good governance to cities [1]. KBUD purposefully designs a city to encourage the generation, circulation and use of knowledge in an economically secure, socially just, environmentally sustained and well-governed human setting—i.e., knowledge city [2]. Correspondingly, KBUD is concerned with economic, societal and spatial (both the built and natural environment) development along with institutional development as an enabler of the former three [3]—Figure 1 illustrates the conceptual framework of KBUD [4]. Even though today many cities globally are considered successful in setting examples for implementing KBUD concepts, the comparative KBUD performances of these cities are understudied, mainly due to the lack of available comprehensive KBUD performance analysis and benchmarking frameworks. Therefore, this paper introduces a KBUD performance assessment-indexing model—i.e., The KBUD Assessment Model (KBUD/AM). The index is employed for the comparative performance assessment of 11 global knowledge cities—i.e., Birmingham, Boston, Brisbane, Helsinki, Istanbul, Manchester, Melbourne, San Francisco, Sydney, Toronto, and Vancouver—to demonstrate the operational capabilities, and potentials of the index to become an integrated KBUD policy support system (includes both analytical—i.e., decision support system—and intuitive systems —i.e., expert system) and thus inform the policy-making circles of cities.

2. Assessing Knowledge-Based Urban Development Performance

The most comprehensive model developed to date for assessing KBUD performances of cities is the so-called KBUD Assessment Model (KBUD/AM). KBUD/AM is a quantitative performance analysis index that evaluates the KBUD achievements of cities and urban regions based on its large multivariable indicator base. One of the distinctive characteristics of this index is that it is specifically tailored for each case study based on the local circumstances, comparison and benchmark characteristic. Moreover, it provides a flexible weighting opportunity for the sensitivity analysis of the results, and additional statistic procedures—i.e., cluster analysis—for better interpretation of the findings.

2.1 Methodology

The KBUD/AM's methodological approach includes: (i) Utilising an indexing framework for KBUD assessment; (ii) Determining indicators of the framework; (iii) Determining the weightings of the indicators; (iv) Collecting data via primary and secondary data collection techniques; using statistical techniques to scale and normalise data for comparison, and; (v) Conducting statistical and descriptive analyses of the findings. The index consists of a composite indicator, four indicator categories, eight indicator sets and 32 KBUD indicators. Four of the indicator categories correspond to the four development pillars of KBUD—i.e., economic, societal, spatial and institutional. These pillars and the eight indicator sets are derived from the literature and the KBUD conceptualization shown in Figure 1.

The index has a large and flexible indicator base as there are 32 indicators altogether in KBUD/AM that are specifically determined for each city cases. Hence, the indicator set provides a valid broad picture view of KBUD despite the potential limitations of individual measures. These indicators are selected from the prominent KBUD literature [e.g., 5,6,7,8,9,10] with involvement of 25 international KBUD experts on the basis of the following key principles: (i) Measurability; (ii) Analytical soundness; (iii) Comparability; (iv) Geographic coverage; (v) Data availability, and; (vi) Relevance and suitability.

KBUD/AM, as default, uses an equal weighting for its indicators. However, to consider the potential benefits of assigning alternative weightings that may potentially improve the accuracy of the index findings, we determined suitable weighting options for the indicators of the index. The weighting options are determined as a result of a three round Delphi exercise conducted with 25 international KBUD experts [11]. In this Delphi exercise, on top of the original; (i) Equal category and indicator weighting systems, our experts suggested to consider; (ii) Equal category and variable indicator weighting, and; (iii) Variable category and indicator weighting systems. Table 1 illustrates the KBUD/AM structure and alternative indicator weightings.

Following the selection of indicators, KBUD/AM, firstly, requires standardisation or normalisation of the indicator values. The index utilises the *z-score* normalisation technique to reflect the specific distribution of the indicator values and present a relative scale according to the best and worst performers. The z-score normalisation of indicator values is calculated in accordance with the following formula:

$$z = \frac{(x - \mu)}{\sigma} \qquad \text{(Equation 1)}$$

where *z* corresponds to the normalised indicator value, *x, μ* and *σ* subscripts denote data, mean and standard deviation values, respectively. Once normalised values are entered into the index, all indicators are assigned their weightings to calculate the indicator set scores, as specified by the following equation:

$$I_{MEF} = \sum_{i=1}^{n} \frac{MEF_i}{n} * w_i;\ I_{KEF} = \sum_{i=1}^{n} \frac{KEF_i}{n} * w_i;\ I_{HSC} = \sum_{i=1}^{n} \frac{HSC_i}{n} * w_i;\ I_{DI} = \sum_{i=1}^{n} \frac{DI_i}{n} * w_i; \quad \text{(Equation 2)}$$

$$I_{SUD} = \sum_{i=1}^{n} \frac{SUD_i}{n} * w_i;\ I_{QLP} = \sum_{i=1}^{n} \frac{QLP_i}{n} * w_i;\ I_{PL} = \sum_{i=1}^{n} \frac{GP_i}{n} * w_i;\ I_{SP} = \sum_{i=1}^{n} \frac{LS_i}{n} * w_i$$

where *I and w* correspond to the indicator score and the weight, and *MEF, KEF, HSC, DI, SUD, QLP, GP* and *LS* subscripts represent macro-economic foundations, knowledge economy foundations, human and social capitals, diversity and independency, sustainable urban development, quality of life and place, governance and planning, and leadership and support indicator sets, respectively. Then, indicator domain scores for each development domain are calculated, as specified by the following equation:

$$I_{EcoDev} = \sum_{i=1}^{n} \frac{EcoDev_i}{n};\ I_{SocDev} = \sum_{i=1}^{n} \frac{SocDev_i}{n};\ I_{EnvDev} = \sum_{i=1}^{n} \frac{SpaDev_i}{n};\ I_{InsDev} = \sum_{i=1}^{n} \frac{InsDev_i}{n} \quad \text{(Equation 3)}$$

where *I* corresponds to the indicator score and *EcoDev, SocDev, SpaDev* and *InsDev* subscripts represent economic, societal, spatial and institutional development indicator categories, respectively. Lastly, the composite indicator scores are calculated, as specified by the following formula:

$$I_{KBUD} = \sum_{i=1}^{n} \frac{KBUD_i}{n} \quad \text{(Equation 4)}$$

where *I* corresponds to the indicator score, *KBUD* corresponds to the KBUD composite indicator and $KBUD_i$ corresponds to each of the economic, societal, spatial and institutional development indicator category scores. After calculation of the KBUD performance scores and rankings of the case cities, the methodology of the KBUD/AM includes one last step—i.e., cluster analysis. This statistical analysis is undertaken to understand how assessed cities are grouped together. The cluster analysis provides an additional angle in the interpretation of the results—revealing insights on better understanding the similarities and differences between cities and the gap between them.

2.2 Case Study

In the era of a global knowledge economy, cities that seek to increase their competitive edge, become destinations for talent and investment and provide prosperity and high quality of life to their inhabitants have little chance of achieving these goals without forming effective KBUD strategies [12,13]. However, knowing the exact standing of a city in the global stage is important to adjust its KBUD policies to improve or retain its KBUD performances. This paper measured, compared and evaluated KBUD performances of 11 global knowledge cities—namely Birmingham, Boston, Brisbane, Helsinki, Istanbul, Manchester, Melbourne, San Francisco, Sydney, Toronto, and Vancouver—to demonstrate how such analysis can be undertaken. The city-regions of these knowledge cities are considered in the analysis to take their metropolitan impacts in the account.

2.3 Results

The KBUD/AM overall analysis provides useful findings. The results of the KBUD/AM global knowledge cities indexing exercise are listed in Table 2. The analysis ranks 11 cities based on their 32 KBUD characteristics, and in two out of three weighting system Toronto comes as the top one—where San Francisco leads in one of them. According to the cluster analysis Toronto, San Francisco, Boston, Vancouver, Helsinki, Melbourne and Sydney group closely together, where the ranks of these cities change in the differing weighing systems (Figure 2). The ranking of the last four cities stay the same in all weighting options. However, Istanbul city shows a significant lower performance than Manchester, Brisbane and Birmingham, and thus not located in the second tier cluster with these cities. The cluster analysis forms three significant city clusters—see Clusters A, B, C in Figure 2—according to their performances. Beyond the overall results, it is also possible to look into each 32 indicator, 8 indicator set, and 4 indicator category results and examine them in great detail. However, this is beyond the scope of this paper—for case study raw data and equal weighted index scores see Appendices 1 and 2. Instead, at the rest of the paper we discuss some of the key opportunities the index provides for cities and their administrations.

3. From an Index to an Integrated System

The literature indicates the lack of comprehensive KBUD performance assessment models for cities [14]. The KBUD/AM indexing model so far is the only decision support tool that can be used to measure, benchmark and evaluate KBUD of cities comprehensively. As the conceptual and operational KBUD models presented in the paper reveal that KBUD is a multidimensional and complex in nature. The literature emphasises on the usefulness of integrating expert systems—computer systems that emulate the decision-making ability of a human expert [15]—with the decision support systems in the case of such multidimensional and complex cases in order to enhance the capacity and accuracy of the urban policy-making process [16]. Currently the KBUD/AM index as a decision support tool does not link with an expert system. In the literature such interlinked systems are referred as integrated systems. An integrated system includes both analytical—i.e., decision support system—and intuitive—i.e., expert system—systems, and it is widely claimed that a decision support system would be able to support higher levels of decision-making if one or more of its subsystems—e.g., data base, model base and user interface—is improved or enhanced by artificial or expert system reasoning [17]. Therefore, we are currently working on further developing the index particularly investing on its data entry automation, user-friendly single platform development, and along with the quantitative data being able to process the qualitative data via an expert system. Furthermore, the KBUD/AM index is planned to factor in the longitudinal data to undertake time-series analysis. The index is also going to include a scenario-building component for estimating and evaluating the future scenario alternatives. Thus, KBUD/AM with its improved and integrated system is going to better support the people dealing with complex decision situations in our cities.

4. Conclusions

The research reported in this paper revealed insights for the KBUD performance assessment of cities as follows. Firstly, a comprehensive approach is needed to develop knowledge cities as highlighted by the KBUD conceptual framework (see Figure 1). Solely focusing on economic means proved not to be successful. Therefore, cities pursuing such prosperous development should give enough and equal attention to all pillars of KBUD—i.e., economic, societal, spatial and institutional. Beyond these pillars, the comprehensive KBUD approach should also embed a strong balance, integration, sustainability and organisation capacity in its development process. KBUD/AM is proved to be a highly suitable tool to measure these aspects of our cities.

Secondly, KBUD is a daunting task, and therefore, city administrations and policy-makers need powerful decision and policy support tools and systems to make informed decisions and policies. In this regard, KBUD/AM is a suitable indexing model for providing a snapshot of benchmarked KBUD performances of cities. However, due to the highly complex nature of KBUD decision- and policy-making, the index needs to be further developed as an integrated system containing an expert system for to better support the policy-making processes of our cities—e.g., including expert systems, scenario building tools.

Thirdly, although experiences from other cities and exogenous assets are most valuable in strategizing KBUD, policy makers also need to build their niche along with their unique development characteristics based on their endogenous assets [18]. Only in this way, cities can achieve a successful and most importantly a sustained KBUD that will help them to become successful knowledge cities. In short, the balance between exogenous and endogenous assets, investment and talent plays a role on determining the sustainability and longevity of KBUD and the success of the city. For our KBUD/AM indexing model, this means a further calibration concerning this issue.

Moreover, assessment and benchmarking analyses, like KBUD/AM presented, are highly useful in helping cities to determine and compare their potential and achievements and then benchmark their progress against the high achiever global knowledge cities. It is the benchmarking and comparative analysis that makes possible a clear gap analysis. This also informs the specifics of KBUD strategies, and how they could be reformulated in this specific city case to close the gap and move the city in the needed KBUD progress direction.

Furthermore, the value of KBUD performance measurement was evaluated from two perspectives. At a general level, the key strength is that the indicator system makes it possible to present and analyse complex phenomena, such as KBUD of a city in a compact manner, and provide the big picture view. Benchmarking also provides a point of reference to the results. Furthermore, the analysis proved valuable in better understanding investigated KBUD performance of our cities. Thus, the KBUD/AM process is applicable and provides value for analysis.

Lastly, KBUD/AM represents the logic of a contemporary multivariable comprehensive KBUD analysis. The model certainly has room for further improvements—particularly in the aforementioned areas. Therefore, the empirical measurement results presented in this paper should not be regarded as the absolute truth of investigated cities' KBUD. Rather, it should be considered as an indication of the status of key KBUD variables and as a trigger for debate, further analysis and learning. Furthermore, the carefully described KBUD performance measurement process of KBUD/AM shows how such measurements can be undertaken and which of the key phases should be included in the process.

This can be also used as a basis for the design of similar studies or more pragmatic analyses and for the further development of the measurement methodology.

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